REVIEW COMMENTS AND RESPONSES

Feasibility Study, Quendall Terminals Site,

October 14, 2013 Agency Review Draft Final

Reviewer: EPA Region 10 Review Date: September 24, 2014

ITEM	SECT/PARA	EPA COMMENT	RESPONSE
1	Disapproval of Section 7	**EPA Disapproves Section 7 of the Draft FS.** EPA is disapproving Section 7 of the Respondents' draft final FS, dated October 14, 2013 for the reasons described in Items 2 and 3, below.	
2	Disapproval of Section 7	**Failure to evaluate individual alternatives appropriately and according to EPA NCP rules and RI/FS guidance.** For example: a) **Overall Protection of Human Health and the Environment.** This evaluation criterion provides a final check to assess whether each alternative provides adequate protection of human health and the environment. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. i. The Respondents failed to completely consider all aspects of the criterion "Overall Protectiveness…" as described in the NCP and EPA guidance. The Respondents only evaluated whether an alternative met each RAO and neglected considering long-term and short-term effectiveness and whether all ARARs were met or not. EPA, by including these other factors into the evaluation of Overall Protectiveness, the Agency determined that Alternatives 1 through 6 cannot satisfy the criterion "Overall Protectiveness of Human Health and the Environment". Additionally, EPA concluded that Alternatives 7 through 10 could satisfy the criterion, "Overall Protectiveness" because either one or more MCLs would be met throughout most of the plume, if not all of it. In cases where MCLs could not be met, a Technical Impracticability waiver would likely be granted. b. **Compliance with ARARs.** The criterion to comply with ARARs or obtain a waiver should be individually evaluated for each alternative and also addressed in the	

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		comparative evaluation of alternatives in the appropriate locations sin the discussions. i. The Respondents consistently ignored acknowledging that MCLs could be met for one or more of the Indicator COCs in various locations of the groundwater plume before a 100 years pasted. EPA has explained a number of times, compliance with ARARs is made on a COC basis by media and to the extent practicable. The Respondents own modeling results indicate that Alternatives 8 and 10 could result in restoration of groundwater to the MCL for benzene. Additionally, the Respondents results also show that the plume exceeding MCLs can be dramatically reduced by Alternatives 7 through 10 and for the portions of groundwater that exceeded MCLs, a TI waiver could be granted. A TI waiver and/or compliance with MCLs would be sufficient to fully comply with the threshold criteria regarding compliance with ARARs. c. **Long-term Effectiveness and Permanence.** The RI/FS Guidance states "(t)he primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The following components of the criterion should be addressed for each alternative: i. Magnitude or residual risk – This factor assesses the residual risk remaining from untreated waste or treatment residuals at the conclusion of remedial activities…" ii. Adequacy and reliability of controls – "(t)his factor assesses the adequacy and suitability of controls, if any, that are used to manage treatment residuals or untreated wastes that remain at the site." The Respondents evaluation for each alternative only focused on whether source control RAOs were met or not and the mechanism for controlling contamination left in place by describing various engineering controls. There is no discussion about the potential risk of the contamination left on-site. EPA	

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		revised the discussion of this criterion in Section 7 to discuss risk by presenting quantitative measures "of the volume or concentration of contaminants in waste, media, or treatment residuals remaining on the site" in accordance with guidance. Additionally, the Respondents discussion of controls was superficial, lacking in any specifics such as the fact that ICs aimed at protecting aquatic remedial actions are unenforceable or that there is little information and field experience regarding the long-term effectiveness of RCM caps.	
3	Disapproval of Section 7	**Biased Assessment of Remedial Technologies.** EPA is also disapproving Section 7 because certain aspects of the evaluation of alternatives were based on several overarching assumptions that resulted in biased evaluations. For example: a) Respondents use the assumption that generation of residuals associated with dredging or excavation are such a disadvantage that any alternative that is removal-based cannot achieve the best balance of pros and cons to justify selection of primarily removal based alternative. For example: i. Respondents discuss at great length the contention that dredging causes unacceptable levels of residuals. EPA acknowledges that residuals especially residuals associated with DNAPL are particularly troublesome. EPA has also made this comment in our comments on the draft FS. The Respondents reference source information that is considered dated at this point. Since that time, there have been advances in dredging technology. In fact, some recent cleanup dredge projects have achieved cleanup numbers on dredged surfaces without incorporating the use of thin sand covers over residual contaminated surfaces. ii. Respondents failed to acknowledge a number of troublesome issues about the use of capping on contaminated sediments. Aside from the fact, that alternatives that rely heavily on the use of aquatic caps, in perpetuity, can be eroded or damaged will require monitoring and maintenance "forever". A cap that fails because it erodes or is damaged can release contamination	

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		for a long time before it is noticed. Whether these releases are not as significant or maybe more significant than dredge residuals is unknowable. iii. Respondents propose the use of some recently developed technologies, amended caps and RCM caps, where there is no field data or experience regarding the long-term use and effectiveness of reactive caps. They show promise however, the many concerns about their reliability was not addressed, such as at Quendall where nearshore bathymetry must be maintained, and if a RCM cap was installed, how is it replaced or repaired without causing releases or badly damaging the habitat. b) However, as noted, residuals can be a result of dredging but Respondents cannot automatically assume that residuals will cause a failure to meet cleanup numbers with today's technology and practices. Respondents fail to pay equal attention to the problems associated with alternatives that rely on ICs, in addition to capping, for remedial protectiveness and reliability. More can be done to prevent exposure to dredge residuals than to ensure the enforcement of ICs.	
4	Disapproval of Section 8	**EPA Disapproves Section 8 of the Draft FS.** EPA is disapproving Section 8 of Respondents' draft final FS, dated October 14, 2013. Section 8 of the FS is deficient. The Respondents' comparative evaluation is based on the evaluation of individual alternatives in Section 7. Unfortunately, because Section 7 is not consistent with the NCP and RI/FS guidance in the way in which many of the NCP 9 Criteria are meant to be applied, or the evaluation is incomplete, Section 8 does not contain justifiable results from the comparative analysis using the NCP's 9 Criteria.	
5	General	**Renamed Alternatives.** EPA has renamed the Alternatives, except Alternative 2, because not all alternatives are containment alternatives. Generally, EPA just deleted the term "Containment" when used for Alternatives 3 through 10. EPA wants each alternative to reflect the difference between alternatives.	

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6	General	**Addition of Alternative 4a.** EPA added the Respondents Preferred Alternative, 4a, into Section 6 and has carried it through the remaining sections of the FS. The text EPA used for Alternative 4a was developed by considering the text for Alternatives 3 and 4 and the Respondents' March 14, 2014 Technical Memorandum. Where information was lacking EPA considered information in Alternatives 3 and 5 as suggested by the Respondents. EPA stated several times that the Respondents should provide the same information for Alternative 4a as they provided to EPA for the other alternatives. EPA never received a complete set of information for Alternative 4a.	
7	General	**Habitat Area.** The Habitat Area shall not contain a PRB or collection trenches or other remedial technology without the permission of EPA, the Muckleshoot Tribes and Trustees. These technologies are incompatible with the purpose of the Habitat Area and cannot be maintained or replaced without significant damage to the Habitat Area. In addition, EPA does not want discussions about potential alternations of the shoreline in the FS —this is a remedial design issue. Additionally, so little information has been provided by the Respondents that EPA cannot comment on the concept of shoreline alternation. This is an issue for RD and would also be dependent on the alternative selected as the remedy for Quendall.	
8	General	**Renton SMP.** EPA has determined that the Renton SMP is not an ARAR.	
9	General	**Risk-based PRGs at 10^{-6}.** EPA has identified risk-based PRGs at a risk level of 10^{-6} in the Draft Final FS. The exception is naphthalene in groundwater, where a RBC of 1.4 ug/L based on a risk level of 10^{-5} is used, for reasons provided in the text.	
10	General	**Impermeable Caps.** The Respondents cannot make claims that impermeable caps associated with future development can impact DNAPL mobility, etc., with the implication that it would aid remediation unless the Respondents want to install an	

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		impermeable cap during remedial action. Otherwise, the occurrence of an impermeable cap is speculation.	
11	General	**Thermal Treatment.** The type of thermal treatment will be determined in RD. The term "thermal desorption" was often used and not well-defined. Thermal desorption can refer to a number of different thermal treatment systems, especially when the temperature range is not specified, or whether an afterburner is coupled with the treatment system. Therefore, the term "thermal desorption" is replaced by the term "thermal treatment".	
12	General	**RCM Caps.** EPA has a number of concerns regarding the use of RCM caps. There is little, if any field data, on the service life of reactive materials as used in various technologies. Analytical calculations are used to "estimate" the service life or replacement rate of reactive materials. Additionally, the replacement process has not been described and the impacts associated with removing or adding additional material when needed. The obstacles to be encountered at Quendall when placing or removing RCM caps has not fully been addressed. The placement of a RCM could be compromised by the extensive amount of wood debris in or on the Quendall sediments. These issues have not been discussed sufficiently in the FS, especially in the evaluation of alternatives.	
13	General	**One Process Option.** EPA does not see a reason to include more than one process option in a given alternative (e.g., amended sand cap and RCM cap), as that decision can be considered during remedial design. EPA eliminated the amended sand cap and used the RCM cap as the representative process option.	
14	General	**ENR Area**. EPA changed the ENR area to be determined as twice the BTV rather than 8 times the BTV.	
15	Executive Summary	1. Replace text with Attachment 4. 2. Delete Tables ES-2, ES-3, and ES-4. 3. Renumber remedy component figures to accommodate Alternative 4a.	

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		4. Renumber original Figure ES-14 (projected groundwater restoration) to ES-16 and remove Note 1. 5. Original Figure ES-15 (DNAPL volumes removed or treated) remains Figure ES-15. 6. Delete original Figure ES-16 (reduction in mass flux).	
16	1.1, Modifying Criteria	Add "and Tribal" acceptance to Item 8.	
17	2.0, 1st paragraph, 4th sentence, and elsewhere in the document	Change "*Conner Homes*" to "Barbee Mill".	
18	2.0, 4th paragraph; last sentence	Delete "*(catch and release)*".	
19	3.1, last bullet	Delete sentence "*Tank bottoms from nearby storage tanks were also reportedly placed west of the North Sump, where Quendall Pond is now located.*"	
20	3.1, new last bullet	Add an additional bullet (after the North and South Sump bullet): "Quendall Pond, located near the shoreline, was constructed in an area where tank bottoms from nearby storage tanks were placed. This area also received wastes from North Sump overflows. Waste from Quendall Pond has migrated into adjacent Lake Washington."	
21	3.2, last paragraph, 2nd sentence	Revise to: "Evidence from field observations suggest that interbedded, low-permeability layers in the Shallow Alluvium can stop, slow, or alter migration of DNAPL."	
22	3.2, last paragraph, last sentence	After "*many remedial technologies*", add: "such as pump and treat and *in situ* thermal and chemical treatment".	

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23	3.3, 5th paragraph, 1st sentence	Revise to: "There is no continuous aquitard separating the Shallow and Deep Aquifers; however, the Deep Aquifer is considered to be a semi-confined aquifer, as the vertical hydraulic interaction between the Shallow and Deep Aquifers is limited by the horizontal stratification of the Shallow Alluvium, and varies depending on the location on the Site."	
24	3.5, 5th paragraph, 3rd sentence	Delete: "conservative drinking water-based" from this sentence.	
25	3.5, 5th paragraph, last sentence	Add "at this location" after "low-permeability lacustrine silt/clay unit".	
26	3.5, 6th paragraph, last sentence	Replace last two sentences "*However, four samples…*" with: "There are a few instances of very low detections of benzo(a)pyrene above the MCL in areas outside of the DNAPL "footprint", but they are either bordering on the footprint (2 µg/L in BH-12 and 2.3 µg/L at BH-18A) or are at concentrations very close to the MCL (0.24 µg/L at BH-29A and 0.23 µg/L at WP-4)."	
27	3.5, last paragraph, last two sentences	Change the last four sentences to: "The approximate extent of surface sediment contamination beyond the nearshore groundwater discharge area that is attributable to historical spills along the T-Dock is represented by the area exceeding the cPAH background threshold value (BTV) of 17.5 milligrams per kilogram normalized to organic carbon (mg/kg-OC).[11] The derivation of the BTV is described in Appendix B (B-1). It was used in this FS to approximate the extent of sediments that may require remediation. As depicted on Figure 3-11, approximately 29 acres of sediments at the Site exceed the BTV."	
28	3.6.2.3, 1st paragraph, 2nd sentence	Change "*transition zone*" to "transition zone between groundwater and surface sediments/porewater".	

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29	3.6.2.3, 2nd paragraph, last sentence	Replace with: "The model was used to simulate downward flux of sulfate from overlying lake water, and the results are consistent with the reduction in BTEX and LPAH concentrations over the last several feet of transition zone between Site groundwater and the surface water of Lake Washington. Sulfate reduction processes may be occurring at the Site (even though there are no data to confirm sulfate reduction).	
30	3.8, 3rd paragraph, 3rd and 4th sentences	Replace with: "The migration of dissolved indicator chemicals in groundwater is primarily controlled by the advective east-to-west groundwater flow and contaminant-specific mobility. Benzene and naphthalene are relatively mobile and, based on both empirical data and groundwater modeling, have likely migrated deeper primarily due to dispersion (to more than 110 feet bgs, impacting groundwater in the Deeper Alluvium), and further downgradient (i.e., toward Lake Washington) from DNAPL source areas compared to the less mobile cPAHs.	
31	4.0	Replace with Attachment 2.	
32	5.0, 2nd paragraph, last sentence	Replace "*It is expected…*" with: "Remedial technologies/ process options are defined in the Record of Decision; however, during remedial design minor changes in a particular process option, such as exchanging the type of reactive material to be used in a RCM, maybe considered if its implementation results in comparable or improved long-term effectiveness and reliability, lower cost, or a comparable or improved rating of any of the other CERCLA evaluation criteria. However, replacing one technology, such as an engineered sand cap for another technology, such as an RCM, could be viewed as a significant change and warrant an additional detailed technical evaluation and potential Explanation of Significant Differences.	
33	5.1.1, 1st paragraph, 1st sentence	Replace "*engineering or institutional controls*" with "engineering controls or control of exposure to hazardous substances by use of institutional controls".	
34	5.1.1, first bullet	Replace with:	

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		"**Institutional Controls.** Institutional controls are non-engineered measures that may be selected as remedial or response actions typically in combination with engineered remedies For example, institutional controls may include administrative and legal controls that minimize the potential for human exposure to contamination by limiting land or resource use (EPA 2000). The NCP sets forth environmentally beneficial preferences for permanent solutions, such as complete elimination risk or treatment of principal threats waste rather than control of risks using containment for example. Where permanent and/or complete elimination are not practicable, the NCP creates the expectation that EPA will use institutional controls to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants. It states that institutional controls may not be used as a sole remedy unless active measures are determined not to be practicable, based on balancing trade-offs among alternatives (40 CFR 300.430 [a][1][iii])." Add (EPA 2000) to the references: EPA, 2000, Institutional Controls: A Site Manager's Guide to Identifying, Evaluating, and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups. OSWER 9355.0-74FS-P. EPA 540-F-00-005. September, 2000.	
35	5.1.1, 5th bullet	Move "Removal" bullet to after "Ex Situ Treatment" and before "Disposal".	
36	5.1.1, 6th bullet	Revise to: "*Ex situ* treatment technologies destroy or immobilize contaminants in media that have been removed from the media surface or subsurface."	
37	5.2, 2nd bullet	Revise "*PAHs*" to "carcinogenic PAHs (cPAHs)".	
38	5.2, 3rd paragraph, 2nd sentence	Revise to: "Subsurface conditions, such as fine-grained soils, heterogeneous subsurface or lack of a continuous aquitard, can limit the effectiveness of many types of containment and groundwater collection technologies."	
39	5.3.1.1	Fix typo: "optiozns"	

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40	5.3.1.1, 2nd paragraph, 1st sentence	Revise to: "These institutional controls can be effective when combined with active remediation such as capping sediments, are implementable under a wide range of conditions, and generally apply to the entire Site."	
41	5.3.1.3, In Situ Thermal, 3rd paragraph, 1st sentence	Revise to: "*In situ* thermal treatment process options are expected to be more costly than other *in situ* treatment methods and more uncertain in effectiveness for treating creosote or coal tar DNAPL based on limited full-scale application."	
42	5.3.1.3, In Situ Stabilization, 2nd paragraph, only sentence	Change "*potentially effective*" to "largely effective".	
43	5.3.2.1, 2nd sentence	Revise to: "These institutional controls can be effective when coupled with active remediation and implementable under a wide range of conditions and generally apply to the entire Site."	
44	5.3.2.2, 1st paragraph, 2nd sentence	Revise to: "The long-term cap integrity can be maintained through implementation of appropriate institutional controls and targeted long-term monitoring."	
45	5.3.2.2, 2nd paragraph (after three bullets)	Delete: "Although implementation of low permeability and impervious caps are relatively more expensive then permeable caps, they may be appropriate in portions of the Site or for some future Site uses, and can be more effective than permeable caps by preventing infiltration and reducing leaching of contaminants. Permeable caps may be more cost-effective to protect against direct contact with contaminated soil in areas where leaching is not a concern."	
46	5.3.2.3, In Situ Stabilization, 1st sentence	Revise to: "*In situ* solidification/stabilization described in Section 5.3.1.3 for DNAPL is applicable and effective for immobilizing Site COCs in soil as it is the most common remedial technology used at creosote/coal tar Superfund Sites."	

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47	5.3.2.3, Bioremediation, last paragraph, 1st sentence	Delete "*Biodegradation is ongoing at the Site*".	
48	5.3.2.5, Ex Situ Thermal Treatment, Thermal Desorption bullet, 2nd sentence	Revise to: "This technology is effective for VOCs and certain SVOCs, achieving 90 to 99.7 percent reductions…."	
49	5.3.2.5, Ex Situ Thermal Treatment, last sentence	Revise to: "Therefore, thermal desorption has been retained as a representative *ex situ* thermal treatment process option for soil. However, for the purpose of the FS, it will be referred to as "thermal treatment", as the specifications for the treated material and emission standards will be determined during remedial design."	
50	5.3.2.6, Onsite Beneficial Use, 1st paragraph	Fix typo: "use consist include".	
51	5.3.3.4, PRB, 4th sentence	Revise to: "As groundwater flows through the barrier, permeable materials within the barrier sorb dissolved-phase constituents and can promote attenuation."	
52	5.3.3.4, Bioremediation, paragraph after bullets, 1st sentence.	Change "*Biodegradation of Site COCs…*" to "Bioremediation of Site COCs…"	

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53	5.3.4.1, 2nd paragraph, 4th sentence	Delete: "In addition, for alternatives with a dredging component, short-term fish consumption advisories may be required due to the potential for short-term water quality and fish tissue impacts during dredging."	
54	5.3.4.2, Sediment ENR, 2nd to last sentence	Delete: "Specifically, the thin-layer placement has remained stable during 10 years of monitoring".	
55	5.3.4.5, Excavation, 1st sentence	Revise to: "Process options for nearshore excavation include:"	
56	5.3.4.5, Excavation, 1st bullet	Revise to: "Use of long-reaching excavators positioned from upland staging areas to remove contaminated sediment combined with the use of sheet pile containment;"	
57	Section 5.3.4.5, Dredging, 2nd bullet, 2nd sentence	Revise to: "Environmental buckets vary in size and can be retrofitted to address different degrees of sediment hardness. For example, at the Todd Shipyard Sediment Operable Unit at Harbor Island (Todd), large steel plates were soldered to the sides of an environmental bucket to provide more weight for penetrating sediments. Appropriately large environmental buckets can be used to handle debris. For example, at Todd large and cumbersome shipyard debris was successfully removed (see Figure 5-1)." Create a new Figure 5-1 with the figure provided at the end of this comment chart. Caption the figure: "Environmental Dredge Bucket Used at Todd Shipyard, Harbor Island, Washington."	

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58	Section 5.3.4.5, Dredging, 2nd paragraph, 2nd sentence	Revise to: "However, many of these effects are reduced due to recent innovations, increased operator expertise, use of containment (e.g., sheet piles, silt curtains, booms), best management practices (BMPs) (e.g., production rates, bucket control, etc.), and/or by equipment selection. Recent dredging events at the Boeing facility on the Duwamish River were accomplished without exceedances of sediment cleanup numbers."	
59	Section 5.3.4.6, Ex Situ Treatment, 2nd paragraph, 1st sentence	Revised to: "Thermal desorption is equally effective as vitrification and incineration in treating VOCs and some SVOCs in excavated sediment but at a much lower relative cost; . . . "	
60	Section 5.3.4.6, Ex Situ Treatment, 2nd paragraph, last sentence	Revise to: "Thermal desorption of sediments may be less effective than for soils due to the higher moisture content of sediment and typically requires dewatering of sediments prior to treatment. For the purpose of the FS, the term "thermal treatment" will be used, as the specifications for the treated material and emission standards will be determined during remedial design."	
61	6.0	Replace with Attachment 3.	
62	7.0	Replace with Attachment 5.	
63	8.0	Replace with Attachment 6.	
64	9.0	Add the following references: EPA, 2002, Estimated Per Capita Fish Consumption in the United States. U.S. Environmental Protection Agency, Office of Science and Technology. EPA 821-C-02-003. August 2002. King County, 1999, Lake Sammamish Baseline Sediment Study Sampling and Analysis Plan. Prepared by the King County Department of Natural Resources, Water and Land Resources Division, Modeling, Assessment, and Analysis Unit. August 1999.	

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		King County, 2000, Lake Washington Baseline Sediment Study. Prepared by the King County Department of Natural Resources, Water and Land Resources Division, Modeling, Assessment, and Analysis Unit. June 2000.	
65	Tables 4-1 through 4-3	Replace with tables provided in Attachment 2 (Revised Section 4).	
66	Table 4-4, Soil PRGs	1. Update the RSL reference to May 2014 and update values accordingly. 2. Update table to reflect that the PRG is based is on 10^{-6} rather than 10^{-5}. This includes changes to highlights and footnotes. 3. Change the lead background value from 16 to 17 (16.8 in Table 13 from Ecology, 1994). 4. Remove highlight from the 4.2 mg/kg ecological PRG for benzo(a)pyrene. 5. Provide reference for background concentrations. 6. Remove MCL in the notes. 7. Remove MTCA RBCs (MTCA calculated values are not ARARs; RSLs are more stringent).	
67	Table 4-5, Groundwater PRGs	1. Update the RSL reference to May 2014 and update values accordingly. 2. Update table to reflect that the PRG is based on 10^{-6} rather than 10^{-5}. This includes changes to highlights and footnotes. 3. On the 0.14 RSL value for naphthalene (which will be highlighted as the PRG), add the following as a footnote: "For the purpose of estimating the extent of the naphthalene plume resulting from contamination at Quendall, the RSL of 1.4 ug/L is used (see Section 4.3)." 4. Remove MTCA RBCs (MTCA calculated values are not ARARs; RSLs are more stringent).	

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68	Table 4-6, Surface Water PRGs	1. The 22 ug/L PRG for benzene needs to be revised to 2.2 ug/L (reflecting risk of 10-6). 2. Even though benzene was the only COC identified in the Baseline Risk Assessment, National Water Quality Criteria for human health (water & organism) need to be added for the other COCs and treated as ARARs (supersede RBCs): http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm	
69	Table 4-7, Sediment PRGs	1. Update table to reflect that the PRG is based on 10^{-6} rather than 10^{-5}. This includes changes to highlights and footnotes. 2. Remove the numbers from the notes that are not referenced with a number in the body of the table. 3. Remove fluorene. 4. Note #5 does not make sense. Update to: Fish/shellfish ingestion PRG back calculated from RI Report Table J-7-74, using sediment EPC of 602 mg/kg OC (RI Report Table 7.1-4). 5. Update Fish/Shellfish Ingestion – Site Sediment values as follows: Using a cancer risk of 3.1 x 10^{-3} for benzo(a)pyrene (RI Table J-7-74) associated with a fish EPC of 0.216 mg/kg (wet) derived from a sediment concentration 602 mg/kg OC (RI Table 7.1-4), the RBCs for fish consumption are 19, 1.9, and 0.19 mg/kg OC for 10^{-4}, 10^{-5}, and 10^{-6}. [(602 mg/kg/0.0031 risk)*0.0001 risk = 19 mg/kg OC at 10^{-4} risk] 6. Add a column for ARARs and include the new SMS values for the appropriate COCs. 7. In the “Notes” column on the right side, note that the background threshold value (BTV) of 17.5 mg/kg OC is a 95/95 UTL considered to be a “do not exceed” value for looking at individual concentrations and comparing them to site background. The BTV is an action level as opposed to a PRG.	

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		8. The ecological PRGs are not OC-normalized and should be clearly noted as such.	
70	Table 4-8, PRG Summary	Update to reflect changes in previous tables.	
71	Table 4-9	Insert new Table 4-9 provided in Attachment 2 (Revised Section 4).	
72	Table 5-8, Sediment Process Options Eval.	In situ treatment, bioremediation: Change first sentence to: "Technology widely demonstrated in upland applications, but not in sediment."	
73	Table 6-1, Alts to RAOs	Delete this table. It does not provide information on to what degree and RAO is addressed.	
74	Table 6-2, Assembly of Tech/Proc Options into Alts.	Renumber to Table 6-1 and include information for Alternative 4a. Remove "Containment with" from the names of Alternatives 3 through 10.	
75	Table 6-3, Alternative Summary	Delete this table. It contains inconsistent information.	
76	Table 6-4, Construction Quantities	Renumber to Table 6-2 and include information for Alternative 4a. Remove "Containment with" from the names of Alternatives 3 through 10.	
77	Table 7-1, NCP Criteria	Change "State (Support Agency) Acceptance" to State (Support Agency) and Tribal Acceptance".	
78	Table 7-2, DNAPL Treated/Removed	Include information for Alternative 4a. Remove "Containment with" from the names of Alternatives 3 through 10.	

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79	Table 7-3, IC and LTM Summary	Delete this table.	
80	New Table 7-3, Summary Evaluation of Alternatives	Use Table 8-2 as a basis and update as follows: 1. Remove “Containment with” from the names of Alternatives 3 through 10. 2. Overall Protection of Human Health and the Environment: For Alternatives 1 through 6, “No”. For Alternatives 7 through 10: “Yes”. 3. Complies with ARARs: For Alternatives 1 through 6, “No” with a footnote stating “A TI Waiver would not be granted because PTW is readily accessible and removal or treatment is feasible with currently available engineering technology.” For Alternatives 7 through 10, “Yes” with a footnote stating “It is assumed that a TI waiver would be granted if monitoring data indicate that MCLs may not be met, since all known PTWs would be addressed under this alternative.” 4. For balancing criteria, update with ratings from the text of Section 7.	
81	Table 8-1, Comparative Rating of Alternatives	Delete this table.	
82	New Table 8-1	Duplicate new Table 7-3 and revise as follows: 1. For Alternatives 1 through 6, replace symbols for the balancing criteria with dashes. 2. Add footnote to the Overall Protectiveness of Human Health and the Environment criterion for Alternatives 1 through 6 stating “Because this alternative does not satisfy the Threshold Criteria, it is not carried forward in the Balancing Criteria comparison.”	
83	Figure 3-2	Add Quendall Pond to this figure. Even though officially constructed in 1972, it is the location where tank bottoms were reportedly placed and where contaminated	

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		fluids discharged to the North Sump may have migrated via surface or subsurface flow.	
84	Figure 3-12	Add Quendall Pond to the graphic.	
85	New Figure 5-1	Create a new Figure 5-1 with the figure provided at the end of this comment chart. Caption the figure: "Environmental Dredge Bucket Used at Todd Shipyard, Harbor Island, Washington."	
86	Figure 6-1	Remove altered shoreline depiction.	
87	Section 6 figures, general	Add figures for Alternative 4a and renumber figures accordingly.	
88	Section 7 figures, general	Include information for Alternative 4a.	
89	Appendix A, Section A3, Item 2	Typo: Superscript 2 at the end of the last sentence.	
90	A3.1.2.1, 1st bullet	Provide a range, median, and standard deviation to put the 0.77 mg/L in perspective.	
91	A3.1.3, 1st paragraph	Clarify that heterogeneity in the Deep Aquifer is limited to the relatively thin upper transition zone.	
92	A3.4, 4th paragraph	Provide a brief basis for the statement of no hotspot pumping benefit. The concept of "printing resolution" needs to be explained.	
93	A5.3.4, 4th paragraph	2,500 gpm is acknowledged to be a significant overestimation in the text, but is used to make this option unfavorable – a common theme with the dewatering calculations. This discussion must be augmented to increase facts and minimize broad brush assumptions and conclusions. Without more foundational basis it is hard to evaluate the potential benefits.	

ITEM	SECT/PARA	EPA COMMENT	RESPONSE
94	Table A-1	Footnote 2. Provide additional detail on how f_{oc} values from the references were selected for the model. For example, the use of minimum values allows the COC to be more mobile and thus the size of the baseline plume may be larger than reality.	
95	Table A-2	In addition to average, add minimum, maximum, median, and standard deviation.	
96	Table A-3	Provide rationale for using an arithmetic average over some other statistic to represent these concentrations over an area.	
97	Table A-7	1. Include a note about why the volume of the arsenic plume increases as opposed to no action. 2. Include a note about why the volumes of benzene and naphthalene are higher for Alternative 9 than for Alternative 7. 3. For Alternative 8, benzo(a)pyrene plume volume percent of 67% seems incorrect. Please confirm.	
98	Table A-8	Darcy Flux is confusing – instead of cm/s, show cubic cm/s per square centimeter. Check text for consistency, to be clear that it is not a velocity calculation (DF/porosity).	
99	Figures A-13 through A-21	Add a large note that all applicable contours (for plan view Figures A-13 through A-17 and cross-sections for Figures A-18 through A-21) contain large solidified areas that do NOT contribute to the final plume volumes. Reference Tables A-6 and A-7, where remediated plume volumes are presented, excluding the volume of solidified materials.	
100	Appendix B-1, cPAH BTV Derivation	Replace this appendix with the material provided at the end of the comment chart regarding derivation of the cPAH BTV value.	

ITEM	SECT/PARA	EPA COMMENT	RESPONSE
101	Appendix B-2, Sand Cap Modeling, Section B2-1, 2nd & 3rd paragraphs	The RI versus current FS evaluations are unclear. Using discrete depth porewater concentrations of selected cations and naphthalene and benzene in native sediment, the RI evaluation demonstrated that the significant concentration reductions of naphthalene and benzene in groundwater/porewater entering the lake were not strongly influenced by surface water dilution, but likely other processes such as biotic and abiotic degradation. NO chemical isolation modeling results were reported in the RI. The current effort uses modeling to determine the concentration/mass loading from the natural groundwater/porewater system to the bottom of a cap. (i.e., taking the RI work to the next step). Then the performance of a cap (i.e., what steady state concentrations at the surface water cap interface) is evaluated. The use of the term “current conditions model” is unclear unless the overall modeling process framework is properly given a foundation.	
102	Appendix B-2, B2-1, 3rd paragraph	End of second sentence. Add that the meaning of the constant dissolved source contaminant concentrations is that the input from the natural system to the bottom of the engineered cap is assumed constant. Because the likely process that is reducing naphthalene and benzene concentrations is biologic, then what evidence is there that if the native sediment biota is covered by an engineered cap that the same degradation and thus source term to the bottom of the cap will take place?	
103	Appendix B-2, B2-2.1, 2nd paragraph, 2nd sentence	The constant source includes through the sediments to the bottom of the cap. Again there is confusion of the two uses of the UT model in the FS. The statement that detailed simulation of transport within the underlying soils and groundwater is not necessary is not clear unless you mean that the source term entering the natural porewater/sediment zone is constant for the use of the model to predict natural loading to the bottom of the cap (using cation and actual contaminant concentrations) and that after establishing natural concentration/flux that those	

ITEM	SECT/PARA	EPA COMMENT	RESPONSE
		concentrations/flux will be constant and will be used as input to the engineered cap and that the cap performance will then be evaluated with the UT model. Need to make clear the descriptions of the two uses of the UT model in this FS. Discuss at a high level then point to Section B2-2.2 (Approach) for more details.	
104	Appendix B-2, B2-2.2	Add a summary statement to this section noting that the initial model helps establish the long-term contaminant concentrations/fluxes to the bottom of the cap based on Site data and the second model evaluates the engineered cap performance.	
105	Appendix B-2, B2-3.1 2nd paragraph 2nd sentence	Change "*Since many of the parameters…*" to "Since many of the model input parameters…"	
106	Appendix B-2, B2-3.1 3rd paragraph 1st sentence	Change "*Once the model input parameters…*" to "Once the model input parameters…"	
107	Appendix B-2, B2-3.1 3rd and 4th paragraphs	First uses of the term "cation model". Use consistent terminology throughout this appendix. Suggest using "Cation Model" instead of Initial Model as it is more descriptive; suggest using "Cap Model" or "Cap Evaluation Model" for the modeling used to evaluate the cap performance.	
108	Appendix B-2, B2-3.1 4th paragraph, last sentence	Change "*by increasing degradation rates for these COCs*" to "by increasing biotic and abiotic degradation rates for these COCs".	
109	Appendix B-2, B2-3.2.1.1	Usable data are available from greater than 40 cm. The choice of 40 cm needs additional discussion and foundation.	
110	Appendix B-2, B2-3.2.1.3	Groundwater seepage velocities – clarify real average linear groundwater velocity or Darcy flux?	

REVIEW COMMENTS AND RESPONSES

Feasibility Study, Quendall Terminals Site,

October 14, 2013 Agency Review Draft Final

Reviewer: EPA Region 10 Review Date: September 24, 2014

ITEM	SECT/PARA	EPA COMMENT	RESPONSE
111	Appendix B-2, B2-3.3	The statements in the text do not coordinate well with the referenced figures. There is no real comparison of modeled versus actual data to evaluate the statement that the figures show good agreement.	
112	Appendix B-2, B2-4.3	The question of what will be the input to the bottom of the cap after the cap is installed must be addressed. What effect does adding the cap have on the biotic and abiotic degradation processes?	
113	Appendix B-2, Table B2-1	Add full rationale and discussion for lumping all cations into average cation concentrations.	
114	Appendix B-2, Table B2-2	Add a discussion of why the 40 cm benzene and naphthalene porewater concentrations are higher at 40 cm than at deeper.	
115	Appendix B-2, Figure B2-1	Change “Biodegradation” to “Biodegradation + Abiotic degradation”.	
116	Appendix B-2, Figures B2-2 and B2-3	Several comments: 1. Cap-water interface is really the natural sediment water interface, correct? 2. To what does the label “Underlying Sediment” refer? 3. What is the red bar? 4. What is below 40 cm? These are important figures and need to be complete and standalone. Notes on figures can help add clarity and coordinate better with text.	
117	Appendix B-2, Figure B2-5	Draw the sediment/cap interface boundary on the figure. Is the cap 0-45 cm?	
118	Appendix B-3, General	The analysis is Appendix B-3 is at most a screening-level analysis conducted for the purpose of estimating cost in the FS and a much more robust analysis will be required in remedial design before the need for armoring is accepted by EPA.	

ITEM	SECT/PARA	EPA COMMENT	RESPONSE
119	Appendix B-4, General	Not reviewed.	
120	Appendix B-5, General	New appendix from Draft FS; not reviewed.	
121	Appendix C, Technologies and Process Options	No comments.	
122	Appendix D, Ex Situ Thermal	Additional cost elements for ex-situ thermal technology could include treatment pad installation, sampling and analysis for process control, mobile equipment rental/leasing, utilities, as well as off-gas treatment. Additional details should be provided to support unit costs related to ex-situ thermal, including any potential materials credits following construction completion. (Comment from Draft FS, not addressed.)	
123	Appendix D, Dredging BMPs	Costs for dredging BMPs could lead to a significant increase in per-cubic-yard cost for dredging. Respondents should describe how these are represented in the 25% contingency. (Comment from Draft FS, not addressed.)	
124	Appendix D, In situ Stabilization, Treatability Studies	The Draft FS does not provide specific cost assumptions for required treatability studies, nor information on what was included in contingency costs, and should specify such detail. (Comment from Draft FS, not addressed.)	
125	Appendix D, General Mob/Demob	Please note if the Mob/Demob also includes bonds and insurance? Note indicates mobilization, demob, & temp facilities. (Comment from Draft FS, not addressed.)	
126	Appendix E, Eng. Calculation Sheets	Not reviewed critically for Draft FS (only for reference); also not reviewed critically for Draft Final FS.	

ITEM	SECT/PARA	EPA COMMENT	RESPONSE
127	Appendix F, Shoring Design Considerations	New, not reviewed.	
128	New Appendix G	EPA requires the “Baseline Wetland and Habitat Report” to be included in an appendix to the Final FS.	

FIGURE 5-1
Environmental Dredge Bucket Used at Todd Shipyard, Harbor Island, Washington

Determining a Background Threshold Value for Carcinogenic PAHs in Sediment

Introduction

The purpose of this appendix is to document the development of the sediment background threshold value (BTV) for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) used to estimate the area requiring remediation in the offshore portion of the Quendall Site.[1] The BTV was developed based on an evaluation of cPAH sediment samples collected in the vicinity of the Site that have concentrations of cPAH resulting from human activities that are unrelated to releases from the Site.[2] The BTV will be used to assess the extent of cPAH contamination that is attributable to the Quendall Site for the purposes of establishing a remediation footprint for the Feasibility Study (FS).

Offsite sediment samples to characterize local non-site-related cPAH concentrations were collected during the 2009 Quendall Remedial Investigation (RI) (Anchor QEA and Aspect 2012). These samples were collected because preliminary risk calculations for human consumption of fish from Lake Washington, based on available Lake Washington sediment data for cPAH (King County 2000) and conservative biota-sediment accumulation factors and EPA default shellfish ingestion rates, indicated an excess cancer risk in the range of 10^{-4} to 10^{-5}. Because a risk-based PRG would be lower than these levels (especially if tribal fish consumption rates were used), this additional data collection effort was included in the Quendall RI (described as a "background study").

Regarding the use of the term "background", the revised State of Washington Sediment Standards (SMS) include definitions for, and the applicability of, both natural and regional background sediment concentrations for use in site characterization and cleanup efforts. At this time, there are no published natural or regional background values for Lake Washington. The purpose of the "background study" for Quendall was not intended to be used to define either natural or regional background as defined in the SMS. The use for these data is limited to what is described in this appendix.

The Final Data Collection Work Plan (Anchor QEA and Aspect 2009) includes details of the study design. Appendix H of the RI Report includes preliminary statistical evaluation of these offsite data. This appendix describes further evaluation of the offsite data as they apply to the FS.

A brief summary of the offsite cPAH sediment study design, the sampling results, and data usability is provided below to provide context. The remainder of the appendix includes documentation of the BTV development, its anticipated use, and cited references.

Brief Summary of the Offsite cPAH Sediment Study Design

The RI field investigation included collection of 20 surface sediment samples (0 to 4 inches below the mudline) along two transects, approximately 1 mile north and 1 mile south of the Quendall Site along the eastern Lake Washington shoreline. Sediment samples were collected at similar water depths and in similar depositional sediment environments to those at the Quendall Site. In accordance with the Final Data Collection Work Plan, ten of the 20 samples (five from each of the north and south transects) were randomly selected and analyzed for PAHs and total organic carbon (TOC).

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[1] Total cPAHs expressed as benzo(a)pyrene toxicity equivalency quotients (TEQs) using toxicity equivalency factors (TEFs) per California Environmental Protection Agency guidance (CAEPA 2009) and summing the results. When calculating a cPAH TEQ, 1/2 the detection limit was used for non-detects (U-flagged results); the maximum detection limit was used in cases where all seven cPAHs are non-detects.

[2] Per WAC 173-340-200 (Definitions): "Area background" means the concentrations of hazardous substances that are consistently present in the environment in the vicinity of a site which are the result of human activities unrelated to releases from that site.

Offsite Sample Analytical Results and Usability

The 2009 RI background data are presented in Table 1. As indicated in Table 1, dry-weight total cPAH values ranged from 0.038 mg/kg (BG-02) to 0.241 mg/kg (BG-03). TOC values ranged from a low of 1.85 percent (BG-03) to a high of 3.95 percent (BG-13). The results for each sample were normalized to organic carbon by dividing the dry weight concentration by the percent TOC. Organic carbon normalized (OCN) cPAH values ranged from 1.71 mg/kg-OC (BG-02) to 13.02 mg/kg-OC (BG-03).

The data were validated by a third party per the Final Data Collection Work Plan and determined to be usable. Another aspect of evaluating usability included mathematical outlier testing, which was conducted to evaluate whether data were sufficiently elevated to merit further review of being truly representative of background. Outlier testing was conducted using ProUCL (Dixon's outlier test), as documented in Attachment H1 of Appendix H in the RI Report.

For the individual and total cPAH data (dry-weight basis) and TOC, none of the data points were determined to be outliers. However, several of the individual OCN PAHs and one OCN cPAH value were identified as outliers. All coincided in sample BG-03, which had several of the highest dry-weight PAH concentrations (none of which are outliers as dry-weight values) but also had the minimum TOC observed (not an outlier among other TOC values). The significantly elevated OCN results for BG-03 are therefore the result of coincident maximum (but not significantly different) PAH concentrations with the minimum TOC observed; hence, the results are an artifact of calculated ratios. Therefore, because the dry-weight cPAH and TOC values were not statistical outliers, it was concluded that all dry-weight and OCN data were suitable for determining background statistics, and therefore none of the 10 samples were excluded.

Derivation of the BTV

For the purpose of the FS, a BTV for the OCN values has been calculated as a 95/95 UTL (upper tolerance limit), which is a 95% upper confidence limit of the 95th percentile. This equates to having 95% confidence that the UTL will contain at least 95% of the distribution of observations in "background" or in any distribution similar to background. While EPA guidance does not explicitly restrict consideration to 95/95 UTLs, several guidance documents do give them the greatest focus (USEPA, 1992; 2002; 2009).

Using ProUCL algorithms, the recommended data distribution for the offsite dataset is a gamma distribution (see Attachment 1). When most of the results are detected (all ten results are), ProUCL allows consideration of parametric (distribution-based) methods for calculating the UTL (as opposed to a non-parametric method) and these data were found to adhere to a gamma distribution. The Hawkins Wixley approach offers a UTL when the data suitably adhere to a gamma distribution.[3]

The 95/95 UTL for cPAH calculated based on the 10 offsite surface sediment samples is 17.5 mg/kg OCN. The 95/95 UTL calculated for bulk sediment cPAH concentrations is 0.321 mg/kg.

Note that Ecology's Draft Sediment Cleanup Users Manual II recommends the use of the 90/90 UTL calculated from a background population to establish the background-based cleanup levels (Ecology, 2013). For purposes of comparison, these values were also calculated. The 90/90 UTL for cPAH calculated based on the 10 offsite surface sediment samples is 12.1 mg/kg OCN. The 90/90 UTL calculated for bulk sediment cPAH concentrations is 0.264 mg/kg.

Selection and Application of the BTV

The PRG of 17.5 mg/kg OCN for cPAHs was selected for use as the BTV to identify offshore areas of the Quendall site that are addressed in the FS. Delineation of site-impacted sediment using the 95/95 UTL

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[3] The Hawkins Wixley approach is an approximation in that it is based upon the transformation $Y = X^{1/4}$ which is built into USEPA's ProUCL since this transformation tends to follow an approximately normal distribution.

results in a sediment remediation footprint that encompasses footprints based on other the areas of the Site offshore that exceed other ARARs and PRGs such as the freshwater benthic SMS criteria for total PAHs, and direct contact PRGs for human health and ecological receptors (including PAH equilibrium benchmark partitioning quotients). The extent of Site impacts delineated using the 95/95 UTL of 17.5 mg/kg OCN results in an area of approximately 29 acres.

Use of the 90/90 UTL of 12 mg/kg OC to delineate Site impacts would increase the size of the footprint to the northeast, where concentrations are in the 12 to 16 mg/kg OC range. However, given the distance away from the primary source of contamination, there is greater uncertainty as to whether these concentrations are related to contamination from Quendall.

References

Anchor QEA and Aspect Consulting. 2009. Final Data Collection Work Plan, Remedial Investigation/Feasibility Study, Quendall Terminals Site, Renton, Washington. Prepared for U.S. Environmental Protection Agency, Region 10 on Behalf of Altino Properties, Inc. and J.H. Baxter & Co. June 2009.

Anchor QEA and Aspect Consulting. 2012. Final Remedial Investigation Report, Quendall Terminals Site, Renton, Washington. Prepared for U.S. Environmental Protection Agency, Region 10 on Behalf of Altino Properties, Inc. and J.H. Baxter & Co. September 2012.

King County. 2000. Lake Washington Baseline Sediment Study. Note data for the RI evaluation were compiled from Ecology (2008) EIM database (documentation is not available).

USEPA. 1992. Statistical Analysis of Ground-water Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance.

USEPA. 2002. Memorandum: Role of Background in the CERCLA Cleanup Program. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. OSWER 9285.6-07P. April 26.

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance, Office of Resource Conservation and Recovery. EPA 530/R-09-007. March, 2009.

USEPA. 2010. ProUCL Version 4.1 Technical Guide (Draft), Office of Research and Development. May, 2010.

Washington State Department of Ecology (Ecology). 2013. Draft Sediment Cleanup Users Manual II, Guidance for Implementing the Cleanup Provisions of the Sediment Management Standards, Chapter 173-204 WAC. Publication no. 12-09-057. December 2013

TABLE 1
Summary of 2009 Quendall RI Offsite Surface Sediment Data

Location Name	BG-02	BG-03	BG-04	BG-06	BG-09	BG-12	BG-13	BG-15	BG-17	BG-19
Dry Weight (mg/kg)										
Benzo(a)anthracene	0.017	0.13	0.082	0.046	0.037	0.028	0.13	0.066	0.041	0.095
Chrysene	0.033	0.21	0.16	0.097	0.064	0.046	0.23	0.1	0.071	0.12
Benzo(b)fluoranthene	0.037	0.17	0.16	0.11	0.093	0.064	0.24	0.085	0.07	0.099
Benzo(k)fluoranthene	0.03	0.18	0.13	0.079	0.066	0.052	0.15	0.068	0.059	0.097
Benzo(a)pyrene	0.026	0.18	0.12	0.091	0.073	0.054	0.16	0.06	0.05	0.077
Indeno(1,2,3-c,d)pyrene	0.024	0.082	0.058	0.068	0.05	0.049	0.11	0.036	0.025	0.028
Dibenz(a,h)anthracene	0.0063	0.026	0.021	0.025	0.018	0.017	0.041	0.013	0.006	0.0085
Total cPAH TEQ	0.038	0.241	0.167	0.125	0.1	0.075	0.229	0.088	0.071	0.111
TOC (percent)	2.21	1.85	3.23	2.45	2.6	2.67	3.95	3.86	2.76	2.85
Organic Carbon Normalized (mg/kg-OC)										
Benzo(a)anthracene	0.77	7.03	2.54	1.88	1.42	1.05	3.29	1.71	1.49	3.33
Chrysene	1.49	11.35	4.95	3.96	2.46	1.72	5.82	2.59	2.57	4.21
Benzo(b)fluoranthene	1.67	9.19	4.95	4.49	3.58	2.4	6.08	2.2	2.54	3.47
Benzo(k)fluoranthene	1.36	9.73	4.02	3.22	2.54	1.95	3.8	1.76	2.14	3.4
Benzo(a)pyrene	1.18	9.73	3.72	3.71	2.81	2.02	4.05	1.55	1.81	2.7
Indeno(1,2,3-c,d)pyrene	1.09	4.43	1.8	2.78	1.92	1.84	2.78	0.93	0.91	0.98
Dibenz(a,h)anthracene	0.29	1.41	0.65	1.02	0.69	0.64	1.04	0.34	0.22	0.3
Total cPAH TEQ	1.71	13.02	5.16	5.09	3.85	2.83	5.81	2.27	2.57	3.89

Notes:
mg/kg - milligram(s) per kilogram
mg/kg-OC - milligram(s) per kilogram organic carbon (normalized)
OCN - organic carbon normalized
cPAH TEQ - carcinogenic polynuclear aromatic hydrocarbon toxicity equivalency quotient
TOC - total organic carbon

Attachment 1
Quendall cPAH Background ProUCL Output

General Background Statistics for Data Sets with Non-Detects

User Selected Options

From File	Sheet1.wst
Full Precision	OFF
Confidence Coefficient	95%
Coverage	95%
Different or Future K Values	1
Number of Bootstrap Operations	2000

Background

General Statistics

Total Number of Observations	10	Number of Distinct Observations	10
Tolerance Factor	2.911		

Raw Statistics		Log-Transformed Statistics	
Minimum	1709	Minimum	7.443
Maximum	13022	Maximum	9.474
Second Largest	5808	Second Largest	8.667
First Quartile	2631	First Quartile	7.874
Median	3870	Median	8.261
Third Quartile	5144	Third Quartile	8.546
Mean	4620	Mean	8.272
Geometric Mean	3912	SD	0.579
SD	3250		
Coefficient of Variation	0.703		
Skewness	2.194		

Background Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.758	Shapiro Wilk Test Statistic	0.955
Shapiro Wilk Critical Value	0.842	Shapiro Wilk Critical Value	0.842
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% UTL with 95% Coverage	14080	95% UTL with 95% Coverage	21078
95% UPL (t)	10868	95% UPL (t)	11898
90% Percentile (z)	8785	90% Percentile (z)	8211
95% Percentile (z)	9965	95% Percentile (z)	10132
99% Percentile (z)	12180	99% Percentile (z)	15029

Gamma Distribution Test		Data Distribution Test	
k star	2.28	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	2026		
MLE of Mean	4620		
MLE of Standard Deviation	3059		
nu star	45.61		
		Nonparametric Statistics	
A-D Test Statistic	0.404	90% Percentile	6529
5% A-D Critical Value	0.732	95% Percentile	9775
K-S Test Statistic	0.172	99% Percentile	12372
5% K-S Critical Value	0.268		
Data appear Gamma Distributed at 5% Significance Level			

Assuming Gamma Distribution			
		95% UTL with 95% Coverage	13022
90% Percentile	8715	95% Percentile Bootstrap UTL with 95% Coverage	13022
95% Percentile	10519	95% BCA Bootstrap UTL with 95% Coverage	13022
99% Percentile	14489	95% UPL	13022
		95% Chebyshev UPL	19477
95% WH Approx. Gamma UPL	11160	Upper Threshold Limit Based upon IQR	8914
95% HW Approx. Gamma UPL	11286		
95% WH Approx. Gamma UTL with 95% Coverage	16764		
95% HW Approx. Gamma UTL with 95% Coverage	17494		